Estimating Runoff Losses Due to Infiltration in Treatment Facilities and Trenches

Introduction

Where a surface discharge exists that must meet flow control requirements, the Washington State Department of Transportation (WSDOT) would like to make reasonable estimates of reductions in runoff flow rates and volumes that can occur as the runoff passes through upstream treatment facilities and conveyance systems. This guidance, developed in coordination with the Department of Ecology, explains how to use Soil Conservation Service (SCS) or Santa Barbra Urban Hydrograph (SBUH) methods for eastern Washington and the Western Washington Hydrology Model (WWHM) for western Washington to make those estimates and size any necessary downstream retention/detention facilities. These design steps are expected to become available in a future version of MGSFlood version 3.

Before using this guidance to estimate infiltration losses, the designer should have sufficient information to know whether adequate depth to a seasonal high groundwater table or other infiltration barrier (such as bedrock) is available. The minimum depth necessary is five feet for bioinfiltration swales because they are centralized facility. For trenches, the minimum depth of three feet to groundwater should be achieved all along the alignment. This two-foot reduction is allowed because infiltration is occurring over an extended surface area. If the minimum depth is not achieved, the following procedures should not be used. The design of downstream treatment and flow control facilities should not assume any losses due to infiltration.

Bioinfiltration Swale

Bioinfiltration swales are used in Eastern Washington to provide treatment of a certain volume of stormwater. Stormwater in excess of that volume usually overflows into a dry well. However, it could also be directed to surface water. If the surface water is not on the list of waters exempt from flow control, the overflow must meet the peak matching flow control standard. In Western Washington, bioinfiltration swales should be designed such that they infiltrate 91% of the post-developed runoff file predicted by MGSFlood or WWHM. If the overflow from the bioinfiltration swale is allowed to discharge to surface water that is not on the flow control exemption list, the overflow must meet the flow duration standard. The following steps describe how to do that.

1. Where native soils are used, use the procedures explained in Section 4-5.2 of the Highway Runoff Manual (HRM) to determine the long-term infiltration rate. Where the upper layer of the native soils is amended with compost to ensure adequate treatment through the swale, the long-term infiltration rate of the native soil should still be used as a reasonable estimate of long-term performance. The compost material that is added to the native soil probably will not reduce the infiltration rate.

2. In eastern Washington, use SCS or SBUH methods to determine the distribution of the project site runoff (hydrograph) from the appropriate design storm (i.e., the 6-month storm and the 25-year storm). Route the storm into the bioinfiltration basin. Set an overflow height at the 6-month storm, and use the long-term infiltrate rate to determine infiltration volumes and compute the

stage (height) of the water in the pond for each 10-minute time step of the hydrograph. Track the overflow flow rates, if any, for each time step. Compare the peak overflow rate to the pre-developed peak flow rate targets (i.e., half the 2-year and the full 25-year). If they are not achieved, the overflow hydrograph must be used as the influent to a retention or detention facility with orifices or other flow controlling structures that reduce the peaks to the target levels. Alternatively, the storage volume of the bioinfiltration swale can be increased and the analysis repeated to determine compliance.

In western Washington, use WWHM to determine the influent runoff file to the bioinfiltration swale. Route the runoff file into a pond, which actually represents the bioinfiltration swale. Enter the long-term infiltration rate for the swale that was determined in accordance with the procedures referenced above. Specify an overflow elevation. Size the pond such that at least 91% of the runoff file infiltrates. The WWHM will provide an overflow runoff file. Compare the flow duration graph of that overflow runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. Alternatively, the infiltration pond can be sized larger to infiltrate more water than 91% of the runoff file and reduce the size of the downstream retention/detention facility.

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Ecology Embankment

These steps assume:

- That you have sized the embankment in accordance with the design procedures in Section 5-4.2.3 of the HRM; and
- That the embankment is not located above ground that has been compacted. If compaction has occurred, such as in construction of a fill slope, the steps below do not apply. No credit for infiltration losses should be given.

1. Enter the characteristics of the drainage area into the post-developed screen.

2. Sum the impervious areas.

3. If the filter strip that precedes the embankment uses only site soils, represent the filter strip as *grass* on those soils (i.e., till or outwash). If the strip has been amended with compost to meet 10% organic content in accordance with Section 5-4.2.3 and Appendix 5A of the HRM, represent the filter strip as *pasture* on the site soils (i.e., till or outwash).

4. Include the surface area of the Ecology Embankment in the impervious surface area total since all of the precipitation falling directly on it will enter the embankment.

5. Enter any other pervious areas that will drain into the Ecology Embankment.

6. Represent the Ecology Embankment as an infiltration basin/pond with an overflow height of ½-inch. This is done by grabbing the pond icon and placing it below the tributary "basin" area so that the computer model routes all of the runoff into the infiltration basin/pond.

The dimensions of the infiltration basin/pond to be entered in the Pond Information/Design screen are: the length (parallel to the road) of the embankment; the horizontal projection of the width (perpendicular to road and parallel to the direction of runoff flow) of the embankment reduced by the width of the underlying drainage trench; and the Effective Depth of one inch. In WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So in the Riser/Weir screen, enter 0.04 feet (½ inch) for the Riser head and a large Riser diameter (say 1000 inches) to ensure that there is no head build up.

7. Using the procedures explained in Section 4-5.2 of the HRM, estimate the long-term infiltration rate of the native soils beneath the embankment. Enter the appropriate long-term infiltration rate for the theoretical pond of ½-inch maximum depth.

8. Run the model to produce the effluent runoff file from the embankment. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. If the embankment is followed by a trench, the effluent runoff file from the embankment can be routed into the trench that is represented in the model as explained below.

For a dual Ecology Embankment (i.e., two parallel embankments within the median), that is symmetrical, simply indicate that the embankment is twice as long.

Conveyance or Infiltration Trenches

These steps assume that:

- Runoff enters the trench evenly dispersed throughout its length or at the upstream end of the trench;
- Runoff has already passed through a treatment facility, or the trench serves as the treatment facility and meets the soil suitability criteria; and
- The embankment is not located above ground that has been compacted. If compaction has occurred, such as in construction of a fill slope, the steps below do not apply. No credit for infiltration losses should be given.

Represent the trench in the WWHM as a pond with a specified infiltration rate by applying the pond icon.

Case 1: Trenches on Zero Grade (Infiltration Trenches)

In this option, the principal purpose of the trench is to serve as an infiltration facility.

1. Specify the dimensions of the trench in WWHM on the screen, which asks for pond dimensions. The dimensions of the infiltration basin/pond to be entered in the Pond Information/Design screen are: the length of the trench (parallel to the road), the width, and the Effective Depth. To estimate the effective depth, the storage/void volume of the trench has to be estimated to account for the percent porosity of the gravel in the trench. If the standard gravel specification is used

the porosity should be 32%. The void volume can be estimated by reducing the height of the trench by 68% (1-32%). This is the Effective Depth. (This gross adjustment works because WWHM2 (as March 2004) does not adjust infiltration rate as a function of water head. If the model is amended such that the infiltration rate becomes a function of water head, this gross adjustment will introduce error and therefore other adjustments should be made.)

2. In WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So in the Riser/Weir screen, for the Riser head enter a value slightly smaller than the Effective Depth of the trench (say 0.1 feet below the Effective Depth); and for the Riser diameter enter a large number (say 10,000 inches) to ensure that there is ample capacity should overflows from the trench occur.

3. On the Pond Information/Design screen, there is a button, which asks, "Use Wetted Surface Area?" Pushing that button is an affirmative response. Do not push the button if the trench has sidewalls steeper than 2 horizontal to 1 vertical.

4. ***If runoff from the drainage area passes through an Ecology Embankment before entering the trench, a pond icon representing the embankment should be placed ahead of the trench.*** Note the instructions above. The effluent runoff file from the treatment facility (plus any bypass runoff file) is routed into the trench. If any other area, whether part of the project or not, drains directly into the trench, another "basin" icon, with basin characteristics identified on a separate screen, must be used to indicate such drainage.

5. Using the procedures explained in Section 4-5.2 of the HRM, estimate the long-term infiltration rate of the native soils beneath the trench. Enter the appropriate long-term infiltration rate for the trench.

6. Run the model. If there is an overflow, compare the flow duration graph for that overflow runoff file to the appropriate pre-development runoff file graph to determine whether the flow duration standard has been met. If it is not met, either increase the size of the trench until it is met, or route the overflow file into a downstream retention/detention pond and size the pond using the standard procedure.

Case 2: Conveyance Trenches on Grade

In this option, the principal purpose of the trench is to convey water. However, a secondary function of water loss can be estimated. This will help reduce the size of downstream retention/detention facilities.

Conveyance trenches that are on grade, generally following the road profile, can be modeled as a pond with an infiltration rate and a nominal depth.

1. Represent the infiltration trench as a pond. Grab the pond icon and place it below the "basin" icon so that the computer model routes all of the runoff into the infiltration basin/pond***. If a treatment facility precedes the trench, the icon for the facility should appear between the "basin" and "pond icons."*** If any area tributary to the trench does not pass through the treatment facility, that area should be represented by a separate "basin" icon that dumps directly into the trench's "pond" icon.

2. The dimensions of the infiltration basin/pond to be entered in the Pond Information/Design screen are: the length (parallel to the road) of the embankment; the horizontal projection of the width (perpendicular to road and parallel to the direction of runoff flow) of the embankment reduced by the width of the underlying drainage trench; and the Effective Depth of one inch. In WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So in the Riser/Weir screen, enter 0.04 feet (½ inch) for the Riser head and a large Riser diameter (say 1000 inches) to ensure that there is no head build up.

   Note: If a drainage pipe is embedded and elevated in the trench, the pipe should only have perforations on the lower half (below the spring line) or near the invert. Pipe volume and trench volume above the pipe invert cannot be assumed as available storage space.

3. Using the procedures explained in Section 4-5.2 of the HRM, estimate the long-term infiltration rate of the native soils beneath the trench. Enter the appropriate long-term infiltration rate for the theoretical pond of ½-inch maximum depth.

4. Run the model to produce the effluent runoff file from the trench. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field.

Case 3: Conveyance Trenches on Grade with Internal Dams

In this option, a series of infiltration basins is created by placing relatively impermeable barriers across the trench at intervals. The barriers inhibit the free flow of water down the grade of the trench. The barriers must not extend to the top of the trench. A space sufficient to pass water from up gradient to lower gradient basins must be provided.

1. Each stretch of trench (cell) that is separated by barriers can be modeled as an infiltration basin. This is done by placing pond icons in series in the WWHM. For each cell, determine the average depth of water within the cell (Average Cell Depth) at which the barrier at the lower end will be overtopped.

2. Specify the dimensions of each cell of the trench in WWHM on the screen, which asks for pond dimensions. The dimensions of the infiltration cell to be entered in the Pond Information/Design screen are: the length of the cell (parallel to the road); the width; and the Effective Depth (In this case, it is OK to use the trench depth).

3. Also in WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. For each trench cell, the available storage is the void space within the Average Cell Depth. So, the storage/void volume of the trench cell has to be estimated to account for the percent porosity of the gravel in the trench. If the standard gravel specification is used the porosity should be 32%. The void volume can be represented by reducing the Average Cell Depth by 68% (1-32%). This depth is entered in the Riser/Weir screen as the Riser head. (This gross adjustment works because WWHM2 (as March 2004) does not adjust infiltration rate as a function of water head. If the model is amended such that the infiltration rate becomes a function of water head, this gross adjustment will introduce error and therefore other

adjustments should be made.) For the *Riser diameter* in the Riser/Weir screen, enter a large number (say 10,000 inches) to ensure that there is ample capacity should overflows from the trench occur.

4. Each cell should have its own tributary drainage area that includes the adjacent road, any project site pervious areas, and any offsite areas. Each drainage area is represented with a "basin" icon.

5. Up to four pond icons can be placed in a series to represent a trench, see screen below. The computer graphic representation of this appears as follows:
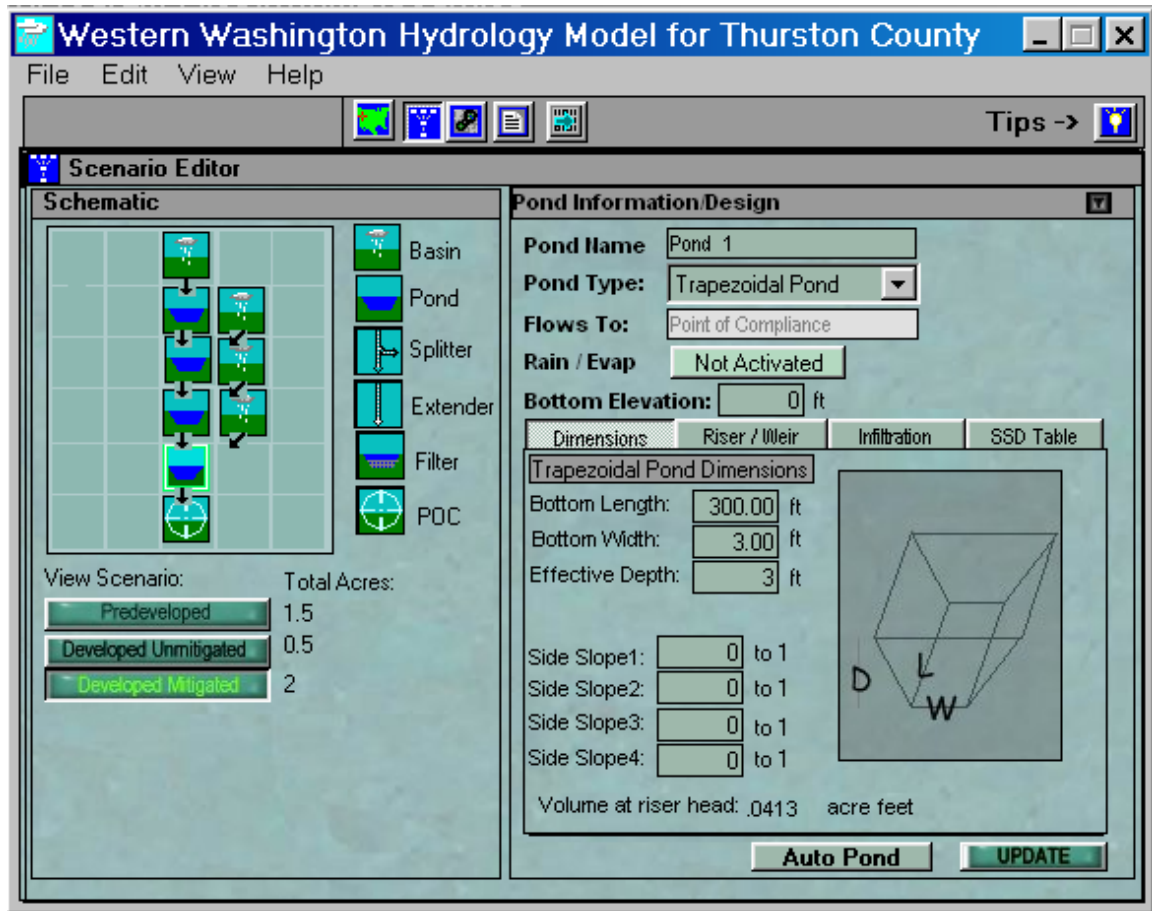
It is possible to represent a series of cells as one infiltration basin (using a single pond icon) if the cells all have similar length and width dimensions, slope, and Average Cell Depth. A single "basin" icon is also used to represent all of the drainage area into the series of cells.

6. On the Pond Information/Design screen (see screen below), there is a button, which asks, "Use Wetted Surface Area?" Pushing that button is an affirmative response. Do not push the button if the trench has sidewalls steeper than 2 horizontal to 1 vertical.

If an Ecology Embankment precedes the conveyance trench, it reduces the number of trench cells possible in the schematic screen. Because the computer model is limited to four elements (ponds, filters, etc.) in series, there isn't sufficient space in the model graphic to represent each Ecology Embankment as an infiltration pond.

7. Using the procedures explained in Section 4-5.2 of the HRM, estimate the long-term infiltration rate of the native soils beneath the trench. Enter the appropriate long-term infiltration rate for the trench.

8. Run the model to produce the effluent runoff file from the trench. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field.